Application of IEL 62305-2 risk analysis standard in France

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APPLICATION OF IEC 62305-2 RISK ANALYSIS STANDARD IN FRANCE

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Abstract - France standard board (UTE) has published IEC/EN 62305-2 in January 2005, more than one year before publication of the standard at IEC or EN level. Purpose was to gain experience when the voting stage occurred for this standard in 2006. UTE has also developped a specific software to apply this risk assessment methode. By now we have more than 2 years of application of both standard and software. The software called Jupiter is just a tool but it helps a lot in introducing data and making easy calculations. This software introduces features such as drawing of the building to calculate accurate collection areas, design of the lines and of circuitry inside the building, evaluation of fire risk existing inside the structure, accurate selection of the needed SPDs as well as an automatic provider of protection solution. This means that studies for simple building may be done by contractors when more complete studies still need to be done by experts but their task becomes a lot easier. This is perfectly in line with the Qualifoudre qualification scheme introduced by INERIS in France. We have now applied this risk method on a large amount of structures with various risks (explosive, radioactive, fire …). Purpose of this paper is to share this experience and to discuss applicability of some parameters introduced in the standard IEC/EN 62305-2.

1 INTRODUCTION

IEC 62305-2 standard for risk assessment has been published in Europe as EN 62305-2, at the latest by October 2006 depending on the countries. When the standard can be implemented or not at IEC level it has to be implemented by law in Europe. France has decided to remove immediately all his previous risk evaluation methods as early as April 2006. This standard is part of the group of new standards that IEC TC81 (International Electrical Commission - technical committee N°81 in charge of lightning protection of structures) has released.
62305-1 deals with general information regarding lightning
62305-2 deals with risk assessment : do I need protection and if answer is yes which one ?
62305-3 deals with lightning protection systems (LPS) : how to set-up such a system and select its components ?
62305-4 deals with lightning electromagnetic pulse (LEMP) : how to set-up and design shields and bonding as well as selection of SPDs (surge protective device) used for equipotentiality ?
France was using so far its own standards for risk (either risk against direct lightning NFC 17-100 or risk against induced surges C 15-443. From time to time we were also using IEC 61662 (ancestor of IEC 62305-2) for complex sites such as military or nuclear plants. Recognizing that method described in 62305-2 is more powerful and consistent than previous methods, French National Committee has decided to publish EN 62305-2 in a draft mature version in January 2005 under number 17-100-2. Purpose of this was to get experience on this method and been able to make comments and propose improvements especially at CENELEC level. Since publication of this document the method has been extensively applied by the authors on many site including chemical sites, explosive sites as well as other industrial sites.

2 IEC/EN 62305- 2 METHOD

The new method is not so different in essence from the original one (IEC 61662) but many parameters have been refined. Opposed to other French methods, this one is purely based on probabilistic calculations and the parameters are coming from international scientific studies which have been largely documented and published (SIPDA, ICLP ...). This is very important as users of the method are sometimes suspicious of the validty of some parameters.

4 sources of damage are defined : flashes to a structure, flashes near a structure, flashes to a service and flashes near a service.
3 types of damages are defined : injuries to living beings; physical damage (damage to the structure i.e. destruction by direct hit, fire, explosion …) and failures of electrical equipments.
4 types of losses are defined : loss of human life, loss of service to the public, loss of cultural heritage and loss of

economic value (structure and its content, service and loss of activity). For each of this loss a risk is defined.

The total risk is then calculated has a sum of risk components defined below :

Risk component for a structure due to flashes direct to the structure :

- RA: component related to injuries of living beings caused by touch and step voltages in the zones up to 3 m outside the structure;
- RB: component related to physical damage caused by dangerous sparking inside the structure triggering fire or explosion, which may also endanger the environment;
- RC: component related to failure of internal systems caused by LEMP;

Risk component for a structure due to flashes near the structure :

- RM: component related to failure of internal systems caused by LEMP;

Risk components for a structure due to flashes to a service connected to the structure :

- RU: component related to injuries of living beings caused by touch voltage inside the structure, due to lightning current injected in a line entering the structure.
- RV: component related to physical damage (fire or explosion triggered by dangerous sparking between external installation and metallic parts generally at the entrance point of the line into the structure) due to lightning current transmitted through or along incoming services;
- RW: component related to failure of internal systems caused by overvoltages induced on incoming lines and transmitted to the structure.;

Risk component for a structure due to flashes near a service connected to the structure

- RZ: component related to failure of internal systems caused by overvoltages induced on incoming lines and transmitted to the structure;

For each of the risk associated to the 4 types of losses (called R1 to R4) and which need to be considered for the studied structure, the total risk will be calculated as a sum of the above described risk components.
Each of the risk components itself will be calculated by using the generic formula given below
$R_X = N_X P_X L_X$
N_X is the number of dangerous events for that risk
P_X is the probability of damage for that risk;
L_X is the consequent loss for that risk
And X can take the values A, B, C, M, U, V, W or Z

The risk component is defined as the number of lightning strikes on the building multiplied by the probability that this strike lead to a damage (hopefully not all strikes will create a damage) and multiplied by a loss factor taking care of the amount of losses (how many people are possibly injured, what are the possible protection measures)
For risk R1 to R3 the total risk need to be lower than the acceptable risk RT given in the standard.

Table 1: Typical values of tolerable risk RT

Types of loss	RT (year-1)
Loss of human life (R1)	10^{-5}
Loss of service to the public (R2) and Loss of cultural heritage (R3)	10^{-3}

For risk R4 there is no tolerable risk as the economic perception is different from a small company to a large group. Calculation is then made by comparing annual amount of losses without protection, annual amount of residual losses as soon as protection measures are implemented and annual cost of protection measures taking care of maintenance. The result is then an annual saving for the owner of the structure.

Let's imagine a telecom center (service to the public) which is located inside a building which is a national heritage. The owner of the building is willing to know if lightning protection will provide some savings to him. In addition, risk for loss of human life needs to be considered as there are some people inside (workers and customers). In such case risk R1, R2, R3 and R4 will be calculated. For each of the risk the appropriate protection measures may differ. For the simplest case of a building where only protection of human being is considered then only R1 will be calculated. R1 is also the risk which is calculated for sites where environemtal risk need to be addressed.

When risk cannot be sufficiently reduced, it is possible to defined specific zones inside the building to better protect the areas which are the more dangerous and avoid overprotecting the complete building.

3 TOOLS DEVELOPED TO APPLY THIS METHOD

As previously mentioned, this IEC standard became a French document in January 2005. As such it is used and will be used more and more and will replace existing documents dealing with the same topic. To allow the use of this standard for most of the lightning professionals it has been decided to provide tools to the user in order to facilitate his job. These tools are described below.

3.1 Forms

INERIS has developed in France a qualification for lightning protection professionals. This is called Qualifoudre. Under this qualification scheme, a professional can claim expertise for site survey, production of lightning protection equipment, set-up of protection measures and control of installations. His expertise in the selected field is attested by a letter which can be S for professional being able to work on simple structures (a house, small office) or C for complex structures (chemical plant for example) or even I for intermediate ones (not a simple nor a complex structure).
The qualification is approved by the Lightning Protection Association (APF), the Ministry of ecology, the Ministery of defense and the Federation of the insurance companies. For companies which are claiming study capability "C" their ability to use UTE C 17-100-2 risk method needs to be proved. Under the Qualifoudre scheme many helping tools are provided to qualified companies, one of them being a form to facilitate on site data collection. As a matter of fact, the new method needs a better cooperation between the plant manager and the lightning engineer. This form (which is sent prior to the survey to the plant manager) is then useful to be sure that there is no misunderstanding on the amount of time the plant technicians need to involve for that action from one side and to be sure that, on the other side, at data collection time, no parameters is forgotten by the lightning engineer

Table 2: Data collection form

Data collection form of a structure to be protected against lightning	
STRUCTURE (N°, name, function)	B1
Dimensions (Length, width, maximum height, height of chimney)	20x20x10 m
Relative situation of the structure	Isolated
Number of floor	1
Type of wall (concrete, metal, wood...)	Concrete
Type of roof (concrete, metal, asbestos cement, tile...)	Tiles
Type of soil inside structure (concrete, linoleum, wood...)	Concrete
Distance between the metal frame	2 m
Resistivity of the ground (ohm.m)	300 Ω.m
Type of soil (clay, granite, silica, humus...)	Clay
Are metal part equipotentially bonded ?	Yes
Are reinforcements of the concrete connected into a mesh ? (mesh size ?)	0,2
Numbers of electrodes for lightning earth.	2
Surge counters (indication on the counter)	1 (0)
Installation of SPDs on the powerlines (type of protection, state).	Type 1 SPDs
Fire protection (simple detection, automatic extinction, extinguisher, presence of fireman or time before their intervention)	Manual fire extingui-shers

Fig. 1. First page (example) of Qualifoudre data collection form

In addition, under the Qualifoudre banner, an internet forum offers possibility to the users of the method to exchange on problems encountered or even to ask for some help.

3.2 Jupiter software

The software is taking into account all the parameters described in the standard and offer to the user practical facilities such as the possibility to test immediately various possible protection means effect and selection of the most convenient one.
Based on the data collected on site, the parameters describing the structure can be filled. There are interesting features in the software such as true calculation of the collection area taking care of real dimensions or evaluation based on fire brigade rules of the fire risk.

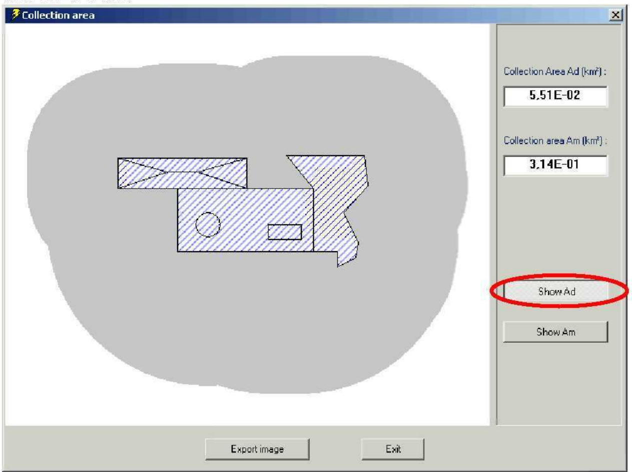

Fig. 1. Exemple of calculation of the collection area

When the data regarding the structure and its connected services are introduced the risk calculation can start. This lead to a diagram as in Figure 2.

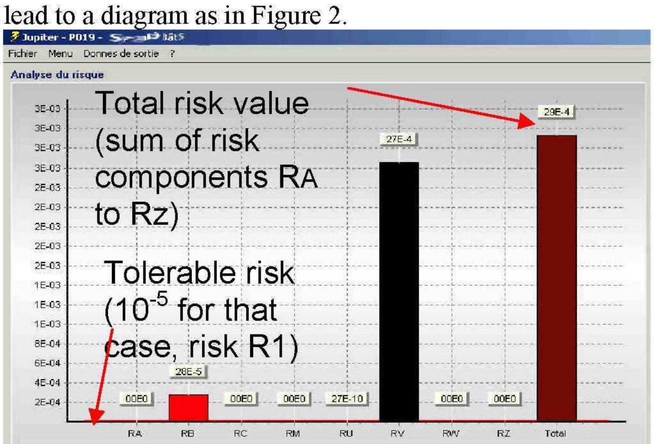

Fig. 2. Typical screen where the protection measures have not been implemented

As it can been seen there is a graphic display of the conclusions of the analysis : the building is not self protected. The user of the software should then introduced protection measures in order to bring the total risk below the red bottom line (tolerable risk)

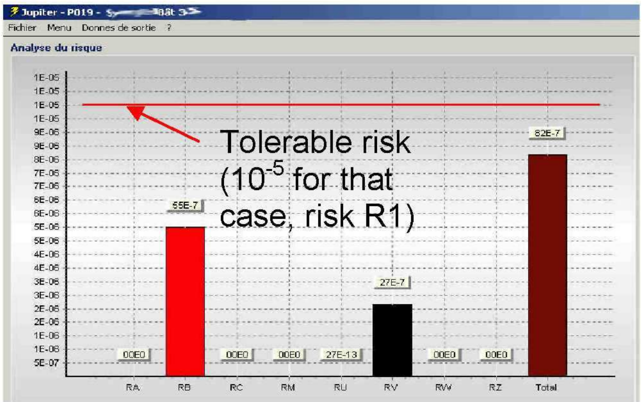

Fig. 3. Typical screen where the protection measures have been implemented

With this software you also have access to many features. One of them is the green/red color code. Every risk component which is red is greater than tolerable risk. It is green in the other case. It is then very easy to determine the part or the zone of structure which needs a special care. This is reported on a specific screen where influence of each zone can be appreciated.

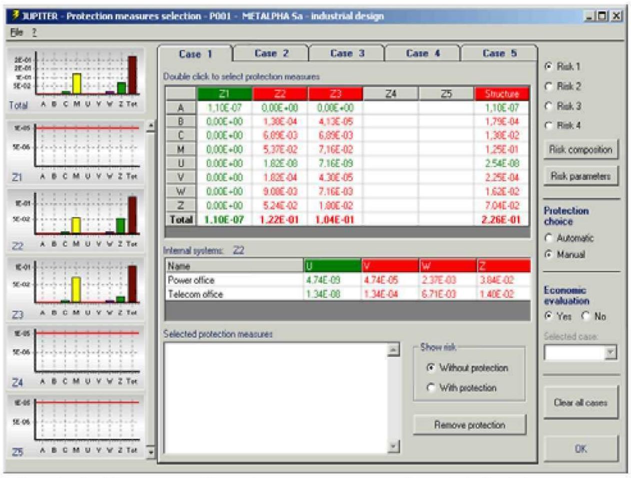

Fig. 4. Influence of various zones on the total risk

The software propose some protection solution in an automatic way that the user can use or not. The economic evaluation and selection of appropriate SPD is also very easy due to a large data base of parameters and cost that the user can manage by himself based on his own experience.

3 APPLICATION OF JUPITER ON EXPLOSIVE SITES

.Sometimes the danger is very high and the potential damages are important. It is the case for installations with risk of explosion and with people in the lethal zone. If the duration of the risk of explosion is not well indicated, the calculated risk can be overestimated. In this case, it happens that the addition of protections with the best possible effectiveness does not reduce the risk under the tolerable value of 10^{-5}. This too huge risk will in fact mask the other risk which even if less important are not minors. A good example is the risk of fire which is often present when there is explosive risk. It is then necessary to consider 2 situations: a normal situation during which the risk is for example the risk fire and a degraded situation where explosion can occur.

Let us suppose that the building to be protected is a warehouse storing solvent. Storage is very flammable and the interior of the building is classified ATEX (level 2) which means explosive atmosphere for short durations not exceeding a cumulative annual time of 100 hours. As the fire risk is present for 1 800 hours we need to consider this duration. But, by considering that storage is explosive and that the people are present in the zone during 1800 hours (even if the potential explosive risk is present for only 100 hours), the risk cannot be reduced with best available protections means.

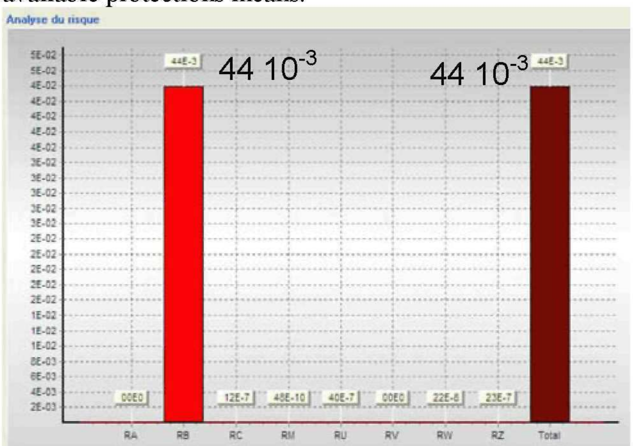

Fig. 5. Protection measures have not been implemented

Calculation must then be carried out for 2 situations. In normal situation only the fire risk is considered and duration is 1 800 hours. It is possible to use protection means to reduce the risk to a tolerable value. In degraded situation, the explosion risk is considered but the duration of presence of the people in the zone at the risk is only 100 hours.

Figure 8 shows that the risk calculated for duration of 100 hours with explosive atmosphere is lower than the tolerable value. The probability that the lightning strikes the warehouse and be the trigger of an explosion is low due to the short duration of 100 hours.

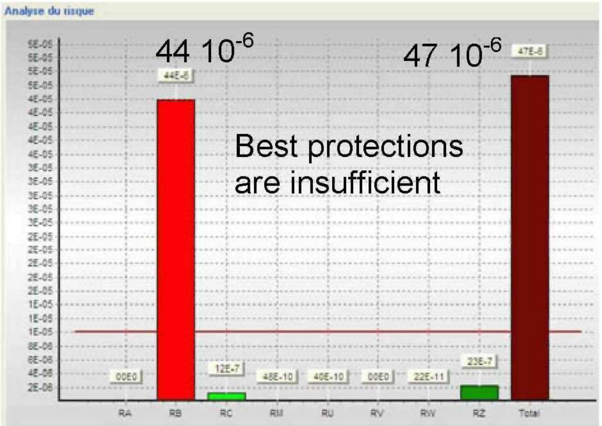

Fig. 6. Best protection measures have been implemented

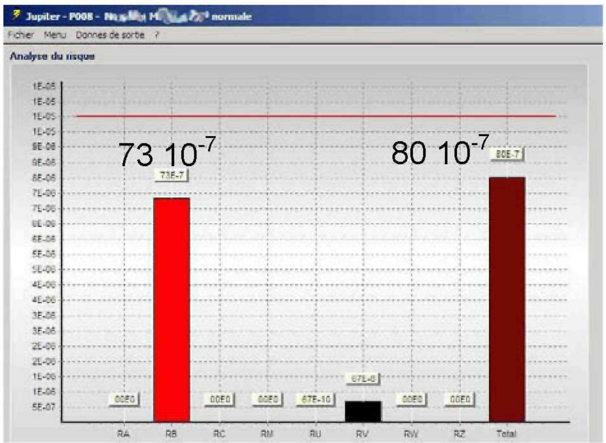

Fig. 7. Protection measures have been implemented

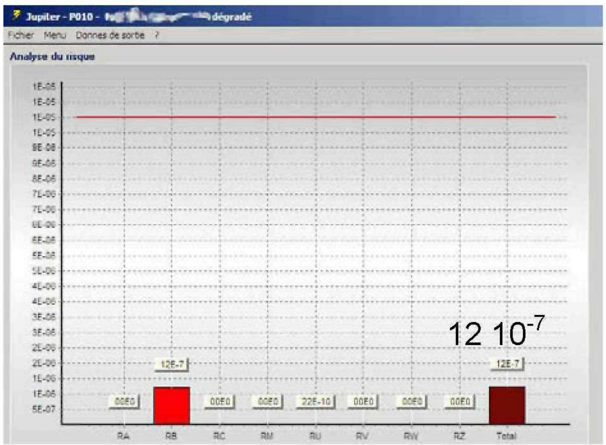

Fig. 8. Whithout protection measures but duration 100 h

When calculation is carried out for various situations, it is then necessary to install the protection means which reduce the risk in all the cases. In the above example, the protection means which reduces the risk as in figure 7 meets the need.

4 NEED FOR CLARIFICATION

No doubt that IEC/EN 62305-2) is a powerful tool. However, it is needed to clarify a few things to cover all the needs of the French lightning protection community (and perhaps of other countries too).
More than 150 buildings have been studied in France using UTE C 17-100-2 method over a period of 2 year. Plants had different characteristics and covered a wide range of industrial site and buildings. Based on application of the method on a large number of cases it appeared that a few parameters needed to be better defined.

4.1 SPDs

There is no relationship between SPD characteristics and probability values that you can select in the standard. Of course, when you are an expert you know how to select the appropriate SPD and if one SPD is better than another. But who is really able to select the probability associated with an SPD which is behaving better than the requirements given by the calculation. An SPD protecting at 1 kV for a fixed value of current offers a better protection than an SPD protecting at 1,5 kV for the same value of current. How can we quantify this? If the needed protection level is 1,5 kV and the needed lightning discharge capacity is 10 kA 10/350 who could say which of the following SPDs is the best? SPD1 has a current capability of 40 kA 10/350 and protective level of 1,5 kV. SPD2 has a current capability of 15 kA 10/350 only but a protective level of 1 kV. It is already not easy to say what is the best choice but it is furthermore difficult to associate probabilities to both. Mainly the document is related to probabilities associated to currents withstand which is probably one of the good parameter to avoid flashover problems at the entrance of installation (but not the only one) but which is quite irrelevant when downstream protection is needed (coordinated SPDs). In addition, to mix SPD with lightning protection level of the LPS creates confusion. What to do when there is no LPS and direct lightning is not relevant? SPD are clarified in Europe by type related to testing capabilities. To have a SPD Type 1 (the one used in case of LPS) defined for a lightning protection level 3 for example can only create confusion. Better coordination is needed between LPS and SPD standards and SPD probabilities should be better defined in the risk standard. Jupiter provides some tools to help selecting appropriate SPDs but the standard should be more detailed regarding this issue and avoid confusion in the head of the reader.

4.2 Concept of coordinated SPDs

You need to use SPDs in front of each sensitive equipment and SPDs should all be coordinated together. But if you use only entrance SPDs (SPDs for equipotentiality) and other SPDs in front of a particular zone (with a high fire risk for example) are you complying with criteria to consider you have a coordinated system? It seems that it is not the case based on present definition when in practice such a protection at needed place will be sufficient.

4.3 Shielding of cables

The key parameter is the shield resistance. Who is able to give this value in practice? Surely not the electrical technician responsible for the building. Should we make measurements? Try to locate the manufacturer reference number and try to get data from him? If you have many days in front of view it is perhaps possible but for most of the cases a simplification is needed. This non practicality will lead countries to develop alternative method for their contractors and this approach is going against the initial target.

4.4 Number of people injured inside a building in case of a lightning strike

In some cases this data can be obtained from discussions between the structure owner or manager and the lightning expert but in a lot of other cases this is quite difficult to achieve. If you use the generic values proposed by the standard you will get a protection scheme which is clearly over designed. In some cases you will not be able to reduce the risk below the tolerable risk and this means according to the French law that you may not be able to run your plant! The only remaining solution is then to install storm detectors and stop this critical activity during stormy periods.

4.5 External zones

They are only considered for the risk of touch and step voltage. But if you have an explosive area in the building or if you store dangerous products with possible impact on environment it is likely that people outside the building will be injured and not due to step and touch voltage. This needs to be considered. In addition, when a toxic cloud is released to the atmosphere in case of surges generated by a lightning strike, how should we consider the number of people potentially injured? 1 000, possibly more … This should be better defined in the standard. In the same way, if a truck is bringing explosive material from the outside, its presence outside of the building should be also taking into account in the explosive risk. Protection of external zone should take into account other aspects than the pure risk of touch and step voltage.

4.4 Storm detectors

So far, the only solution in some cases to reduce the risk below tolerable risk is to use a storm detector. Simple way of doing so is to consider that there is nobody in the dangerous zone in such a case (once again this does not cover the risk of people being outside the building or of a released chemical cloud spreading around). But in fact, a storm detector has also an efficiency. It may not detect 100% of all storms. In some cases, the user will change the settings in order to avoid too many false alarms leading to a detection ratio of less than 100%. In such a case, such a ratio cannot be introduced in the method. Of course, there is no standard for such storm detectors so far in spite of some attempt in France and at Cenelec level, but we cannot ignored such a tool for the risk evaluation and a probability should be associated to it in the same way it is for SPDs or LPS.

4 CONCLUSIONS

French national committee has decided in January 2005 to implement the draft international standard IEC 62305-2 into a French document. This is clearly supported by most of the actors and especially INERIS which has included this requirement in his qualification scheme named Qualifoudre. To support this development, tools have been developed and UTE, the French electrical standard body, has developed a powerful software named Jupiter. This will allow a greater number of people to use the method. At the same time, to allow this general use, a few parameters need to be clarified. They are accessible to the lightning expert, even if in some cases it may be quite difficult to get the data or relate these data to probability values. But for less skilled users, the task may be discouraging. The risk calculation being so powerful it should be a pity to not make the necessary clarifications which will make this document the only reference in lightning risk management.

5 REFERENCES

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